

between that and the next term are found by the processes mentioned in the former part of this paper. The roots of the even numbers are then obtained by an analogous process; and these are used as bases or roots of the polygonal numbers, which are placed in columns, with their sums, as appears in the Table (see Diagram No. 4 for the mode in which the polygonal numbers are formed).

It will be observed that the sum of the roots or bases is 17; but if they be used to form trigonal numbers, the increment of the sum of the resulting trigonal numbers above the sum of the roots or bases is 28, and so on of the rest, each successive column increasing by the same number, viz. 28. If the roots or bases be $n, n, n, n \pm 1$ (that is, a term in the gradation series), the increment of the sums of the successive columns will be $2n^2 \mp n$, a trigonal number.

Again, in the trigonal numbers the difference between the sums of the first and second term is 0; in the square numbers it is 1; in the pentagonal numbers 2; in the hexagonal numbers 3; in the heptagonal numbers 4; but in all of them the difference between the second and third terms is 1, and this continues throughout. The difference between the third and fourth, the fifth and sixth, the seventh and eighth, &c., increases by 1 in each column; but the difference between the second and third, the fourth and fifth, the sixth and seventh, &c., is always 1 in each column; and the result is that, by adding 1 in the pentagonal column, by adding 1, or 1.1 in the hexagonal, by adding 1, or 1.1, or 1.1.1 in the heptagonal, every number, odd or even, can be made by not exceeding four square numbers, or five pentagonal numbers, or, &c., as clearly appears by the Table.

This corresponds with what was discovered by Cauchy, published at the end of Legendre's '*Théorie des Nombres*,' viz. that four only of each class of numbers is necessary; the rest may be supplied by 1 repeated as often as necessary. But I must not omit to say that, although all the odd numbers are sufficiently obedient, there is one class of even numbers quite refractory, viz. the powers of 2. They may be easily expressed in squares, pentagonal numbers, &c., but they cannot be brought within the rule that otherwise prevails.

II. "Compounds Isomeric with the Sulphocyanic Ethers.—I. On the Mustard Oil of the Ethyl Series." By A. W. HOFMANN, LL.D., F.R.S.

The results of my researches on the chloroform-derivatives of the primary monamines, which, as I have shown, are isomeric with the nitriles, could not fail to direct my attention to allied groups of bodies, with the view of discovering similar isomerisms.

In a note communicated to the Royal Society some months ago, I expressed the expectations which even then appeared to be justified in the following manner:—"In conclusion, I may be permitted to announce as

very probable the existence of a series of bodies isomeric with the sulphocyanides. Already M. Cloëz has shown that the action of chloride of cyanogen on ethylate of potassium gives rise to the formation of an ethylic cyanate possessing properties absolutely different from those belonging to the cyanate discovered by M. Wurtz. On comparing, on the other hand, the properties of the methylic and ethylic sulphocyanides with those of the sulphocyanides of allyl and phenyl, it can scarcely be doubted that we have here the representatives of two groups entirely different, and that the terms of the methyl- and ethyl-series which correspond to oil of mustard, and to the sulphocyanide of phenyl, still remain to be discovered. Experiments with which I am now engaged will show whether these bodies cannot be obtained by the action of the iodides of methyl and ethyl on sulphocyanide of silver."

These experiments I have since concluded, but the hopes which I expressed have not been realized. Dry sulphocyanide of silver is much less easily attacked by the alcohol-iodides than the cyanide. The mixture, in consequence of the formation of iodide of silver, rapidly turns yellow, but the reaction is not completed without protracted digestion in the water-bath; on submitting the product of the reaction to distillation, the well-known sulphocyanic ethers, discovered by M. Cahours, are obtained. The experiment was performed both in the ethyl- and the amyl-series; the ethers thus produced, when compared with the compounds prepared by distilling sulphocyanide of potassium with sulphethylates or sulphamylates, exhibited the same odour, the same boiling-point, and in general the same chemical deportment.

The failure of these experiments could not, however, shake my belief in the existence of two series of bodies of the composition of the sulphocyanic ethers. It was only necessary to find the method of producing the new isomers.

I was fortunate enough almost at the very outset to trace the right track, and I beg leave to submit to the Royal Society some of the facts established even now by my experiments. These experiments are intimately connected with some of my older observations.

More than twenty years ago, when studying the action of bisulphide of carbon on aniline, I discovered a finely crystallized body, which in succession has been designated as *Sulphocarbonilide*, *Diphenylsulphocarbamide*, and *sulphuretted diphenylurea*. About ten years later*, this compound again passed through my hands. I then found that, when submitted to the action of anhydrous phosphoric acid, sulphocarbonilide was converted by the loss of 1 mol. of aniline into sulphocyanide of phenyl. The phenyl-compound has the peculiar pungent odour of the ethereal oil of black mustard; like the latter it possesses the faculty of fixing the ammonias—so much so, indeed, that I did not hesitate to describe the new compound as the mustard oil of the phenyl series.

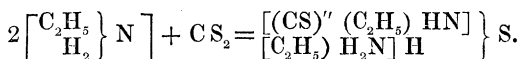
* Proc. of the Roy. Soc. vol. ix. p. 274.

I almost wonder now that the experiments performed in the phenyl series, and soon afterwards also in the naphthyl series, were not even then extended to the ethylic compounds and their homologues—the more so since the study of the action of bisulphide of carbon upon amylamine and ethylamine had, so to say, supplied me with the material for the inquiry. When contemplated in the light of the recent observations, these experiments acquired an increased interest; for I could no longer doubt that the reaction, which had yielded me the sulphocyanide of phenyl, when appropriately applied to the derivatives of methylic, ethylic, and amylic alcohols, would put me into possession of the compounds isomeric with the sulphocyanic ethers which I was anxious to procure. Experiment has not failed to confirm my anticipations.

Experiments in the Ethyl series.

The general character of the action of bisulphide of carbon upon ethylamine I had examined when more minutely investigating the behaviour of amylamine under the influence of the bisulphide*. I have resumed the inquiry, which has furnished me the following results:—

On adding bisulphide of carbon to an alcoholic solution of ethylamine, the liquid becomes more or less heated, according to the concentration of the solution. The liquid turns neutral, and yields on evaporation an oily compound, which after some time solidifies into a mass of splendid tabular crystals. This compound fuses at 103° , and then retains the liquid condition even when cooled to the ordinary temperature. When gently heated, the salt is volatilized, partly, at all events, without decomposition. These crystals are the *ethylamine-salt of ethyl-sulphocarbamic acid*.

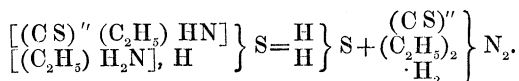


The salt is readily soluble both in water and in alcohol. Addition of soda disengages ethylamine, giving rise to the formation of ethylsulphocarbamate of sodium. Hydrochloric acid decomposes the salt with separation of the acid, which collects in oily drops on the surface of the liquid, gradually solidifying to a mass of fatty crystals. Excess of hydrochloric acid dissolves these crystals, bisulphide of carbon being evolved, and a salt of ethylamine remaining behind.

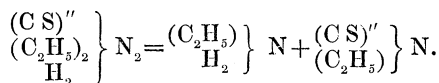
Under the protracted influence of heat ethylsulphocarbamate of ethylamine is thoroughly decomposed.

Even at the temperature of boiling water, torrents of sulphuretted hydrogen are disengaged; the transformation is rapidly accomplished when the alcoholic solution is heated under pressure to 110° or 120° . On evaporating the alcoholic liquid after the evolution of sulphuretted hydrogen has ceased, an oily liquid remains behind, which also crystallizes after some time. These crystals fuse at 77° ; they are likewise soluble in alcohol,

but differ from the ethylsulphocarbamate by their insolubility in water. Hydrochloric acid dissolves them; the solution yields, with perchloride of platinum, a light-yellow precipitate. The new substance is *diethylsulphocarbamide* or *sulphuretted diethylurea*, the formation of which is represented by the following equation:—

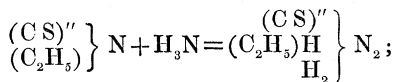


On gently heating a mixture of diethylsulphocarbamide with anhydrous phosphoric acid, pungent vapours are evolved, which are condensed to a yellowish liquid possessing in a remarkable manner the odour of mustard oil. When rectified, this liquid becomes colourless; it boils constantly at 134° , and has the same composition as the sulphocyanide of ethyl which is formed by the action of a metallic sulphocyanide upon sulphethyle of potassium. The new substance is formed by the separation from the diethylsulphocarbamide of one molecule of ethylamine, which unites with the phosphoric acid.

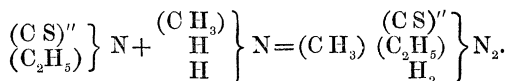


In its properties, the new compound essentially differs from the known sulphocyanic ethylether. The boiling-point of the latter is 147° ; the new substance therefore boils 13° lower than the old one. The powerfully irritating odour of the new ether is absolutely different from that of the ordinary sulphocyanic ether, which, though by no means agreeable, exerts no marked action either upon nose or eyes.

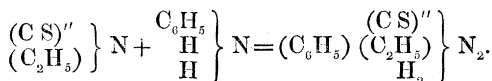
By far the most characteristic feature of the new compound, however, is the facility with which it acts upon ammonia and its derivatives. Dissolved in alcoholic ammonia and digested for a few hours at 100° , the ether is converted into *ethylsulphocarbamide* or *sulphuretted ethyl-urea*.



with methylamine a mixed urea is formed,



Ethylamine produces the diethylated compound which has served in the preparation of the ether; aniline, lastly, gives rise to the formation of a mixed urea of the fatty and aromatic series,



All these diamines are very crystalline; they are weak bases which dissolve in acids, and furnish, with perchloride of platinum, yellow crystalline precipitates.

The faculty of combining with the ammonias, it will be remembered, is altogether deficient in the ordinary sulphocyanic ethers. On the other hand, it belongs to sulphocyanide of allyl, or mustard oil. In fact the new compound is in the ethyl-series what mustard oil is in the allyl-series. I have on this occasion again perused the beautiful memoir of Professor Will on mustard oil, the indications of which have served me as a guide in my experiments. So far as these experiments go, the parallelism of the ethyl- and allyl-body is complete.

For the present I must be satisfied to have indicated the formation and the principal properties of the new compound isomeric with sulphocyanide of ethyl.

In a subsequent paper I propose to communicate to the Royal Society the results of a comparative study to which I have submitted the old and the new sulphocyanide, together with the conclusions elicited by these researches as to the different atomic construction of the two substances.

In conclusion, I may be permitted to state that methylamine and amylamine, when subjected to the same treatment, have furnished me the analogous mustard terms of the methyl- and amyl-group; the properties of these substances I have not yet more minutely investigated.

February 20, 1868.

Dr. WILLIAM ALLEN MILLER, Treasurer and Vice-President,
in the Chair.

Mr. Baldwin Francis Duppa was admitted into the Society.

The following communications were read:—

I. “*Sur l’Origine de l’Électrotone des Nerfs.*” Par M. CH. MATTEUCCI. Communicated by Dr. BEALE, F.R.S.

Depuis mes premiers travaux sur la fonction électrique de la torpille, et sur le courant musculaire de la grenouille et des animaux à sang chaud, qui datent depuis 1837, et que la Société Royale voulut quelque temps après encourager avec sa plus haute distinction, je n’ai jamais cessé de m’acquitter de la dette que j’avais ainsi contracté envers cet illustre corps scientifique, en lui communiquant les recherches successives tentées sur les mêmes sujets, et dont le but constant a été de démontrer les analogies qui existent entre des lois physiques et chimiques connues et les phénomènes électro-physiologiques. Tel est aussi le but de cette communication.

Un fait remarquable d’électro-physiologie est la propriété dont parmi les